CHAPTER 10. STORM DRAINAGE FACILITIES

1001. GENERAL PROVISIONS

(1) A developer shall provide private or public storm drainage easements along existing or proposed open drainage channels that encompass the water course and sufficient adjacent area to handle the flow of design storm described in Section 1002.3.

(2) The developer shall design and construct drainage facilities according to this chapter and the City's Construction Specifications for Public Improvements. The following design criteria are the City's minimum methods and standards. A developer may use other hydrologic and hydraulic design methods to satisfy drainage requirements with prior approval of the City Engineer.

See also Chapter 7 and Sections 205,403, and 702 of this Code.

(3) Except as provided below, the developer shall provide public easements for

(a) facilities that are constructed or used to control storm water flow from several developed properties, or

(b) facilities that a developer desires the city to own or maintain.

(4) The City does not require a developer to provide public easements for storm water drainage if

(a) the facilities that are constructed serve a single property or an association of property owners and

(b) the developer places and records private easements or restrictions on the properties and their uses to privately maintain the drainage facilities. Maintenance of private drainage systems shall be the responsibility of property owners within the development. The property owners shall be legally bound together by deed restrictions, property owners' association, corporation or other organizations that has as one of its purposes the continued care and maintenance of all commonly owned property within the development, including private drainage.

See Sections 205, 403, and 702 of this Code.

1001.1 Upstream conditions

The developer shall design all drainage facilities based on potential and fully developed upstream conditions. A developer shall use a minimum runoff coefficient of 0.75 for all undeveloped upstream property.

1001.2 Downstream conditions

The developer shall determine downstream water surface elevations for a 100-year design frequency storm to define the downstream flood hazards created by the proposed development.

1001.3 Protection of downstream properties

The developer shall design and construct downstream drainage improvements or a retention system to protect downstream properties from any change in storm water runoff.

1001.4 Discharge points

The developer shall end all drainage improvements at a discharge point approved by the City Engineer. The developer shall design and construct such discharge points, or outlets, to prevent damage to or overflowing into adjacent property. The City Engineer may require creek improvement, channel lining, energy dissipaters or other improvements for such outlets to prevent erosion or increase the flow capacity.

1001.5 Public streets as drainage facilities

(1) Maximum depth of water to be allowed in local streets at five (5) year design flow shall be at the top of crown, or top of curb, whichever is least.

(2) Maximum spread of water in collector streets at ten (10) year design flow shall allow for one (1) clear lane of traffic (twelve (12) feet wide).

(3) Maximum spread of water in arterial streets at ten (10) year design flow shall allow for two clear lanes of traffic (twenty-four (24) feet wide).

1001.6 Drainage channels and structures

(1) The developer shall install an underground storm drain on curb and gutter streets beginning at the point where the calculated storm water runoff is of such a quantity that it exceeds the height specified above (see also Table 10-2). The developer shall construct the storm drain system from this point to an approved outlet.

(2) For non-curb and gutter streets, the developer may use open channel (channel or ditch) methods to dispose of storm water runoff of such a quantity that it exceeds the height specified above. Such channels may be in dedicated drainage easements outside the standard street right-of-way upon Planning Commission approval of the location and alignment of such easements. Alternatively, the developer may widen the street right-of-way to hold an open channel of greater capacity than the standard street/ditch section (refer to Figures 6-3 to 6-8).

(3) If the developer locates the channel in a widened street right-of-way, the City Engineer shall approve the right-of-way width and channel configuration.

(4) The developer shall design and construct all channels to end at approved outlets.

1001.7 Habitable structures

The developer shall provide adequate means for storm water runoff more than the streets' "design storm" capacity (i.e., 5,10-year storms) to flow around habitable structures.

(1) If adjacent topography rises away from the street, the developer shall provide a grading/drainage plan that shows that all building sites can provide a finished floor elevation:

(a) at least one foot (l') above the top of the curb using the highest point along the portion of the curb fronting the building site, or

(b) at least one foot (1') above the top of ditch elevation, using the highest point along the portion of the ditch fronting the building site.

(2) If adjacent topography falls away from the street, the developer shall provide a grading/drainage plan that shows that all building sites can provide a finished floor elevation at least one foot above the ground elevation along all sides of the building site.

(3) The developer shall design and construct all streets to minimize any fill required to bring building pads into compliance with this Code.

(4) Alternate methods of building protection of those above may be accepted by the City Engineer upon submittal of detailed, engineered plans.

1001.8 Drainage system criteria

If an underground drainage system is required, and a sixty (60") inch or smaller pipe will handle the design flow, pipe shall be used. If a sixty (60") inch pipe is not adequate, the

developer has the option to use concrete pipe or natural and/or a lined open drainage channel. If pipe is selected, the maximum allowable velocity shall be 8 feet per second (fps) in the pipe. The City Engineer shall approve any lining materials used.

1001.9 Line of flow

The developer shall allow water courses to follow their natural lines of flow; provided, however, a developer may rechannel or reroute water courses where approved by the City Engineer and where the developer does not change the points at which the water course enters the property and the points at which it leaves the property.

1001.10 Bridges and box culverts

The developer shall design and construct bridges or box culverts at all street crossings over all drainageways and floodways according to Table 10-3.

1001.11 Valley gutters

The developer shall provide concrete valley gutters if the gutter flow is carried across intersections of curbed streets.

1001.12 Public easements required

All public drainage facilities shall be placed in public easements as described in Chapter 7: Easement Standards.

1002. DESIGN CRITERIA

1002.1 Basis for discharge

The developer shall design drainage improvements for watersheds less than 1,000 acres based on flood discharges determined from the Rational Formula. See Table 10-2.

1002.2 Determination of time of concentration

Calculate the time of concentration based on the average runoff velocities shown in Table 10-1.

Description of Water Course	Velocity of Run-off in F.P.S. for Slope in Percent			
	0% to 3%	4% to 7%	8% to 11	over12%
Overland Surface Drainage	5	10	15	18
Channels	Determine V by Manning's Formula			
Storm Sewers	Determine V by Manning's Formula			

For street or gutter flow, the velocity shall be based on the grade of the street. Without detailed calculation by Manning's Formula for the specific street section, the average velocities shown in Table 10-1 may be used.

TABLE 10-1
AVERAGE VELOCITIES OF RUNOFF

% Slope of Gutter	Assumed Velocity (Ft./Sec.)
0.5%	1.5
1.0%	2.2
2.0%	3.1
3.0%	3.8
4.0%	4.3
5.0%	4.9
6.0%	5.3
8.0%	6.1
10.0%	6.9

Table 10-2
THE RATIONAL FORMULA

$Q = CIA$, where:

Q = the maximum storm flow rate at a given point (in cubic feet per second);

C = a runoff coefficient that varies with the topography, land use and moisture content of the soil at the time. The runoff coefficient shall be based on the ultimate use of the land. The runoff coefficient can be selected from the major use classification shown below.

Shopping Centers	0.95
Business Areas	0.80
Industrial Areas	0.70
Residential Areas	
(1) less than 2 lots/acre	0.40
(2) greater than 2 lots/acre but less than 4 lots/acre	0.50
(3) greater than 4 lots/acre but less than 8 lots/acre	0.60
(4) greater than 8 lots/acre	0.75
Apartments	0.75
Park and Open Space	0.30

I = the average intensity of rainfall in inches per hour for a period equal to the time of concentration of flow from the farthest point of the drainage area to the point under consideration.

$$I = \frac{b}{(t+d)^e}$$

where d = 8.0 and

	5 year	10 year	25 year	50 year
b =	73	80	84	94
e =	.778	.759	.739	.740

t = time of concentration in minutes

A = the drainage area, in acres, tributary to the point under design calculated from the drainage map of the area. This drainage map shall be submitted with any drainage plans submitted for consideration by the City Engineer.

Using the average velocities in Table 10-1, the developer shall calculate the time of concentration by the formula shown in Table 10-4 or by other recognized formulas such as the Texas State Department of Highways and Public Transportation formulas unless more data is shown on the plans for calculating time of concentration.

1002.3 Storm frequency

Design storm frequencies for storm drainage improvements are shown in Table 10-3.

TABLE 10-3
DESIGN STORM FREQUENCY

Type of Facility	Description of Area to be Drained	Minimum Design Frequency (Years)
Streets and Storm Sewers or Side Ditches, Combined*	Residential, Commercial and Industrial	Local - 5 Collector - 10 Arterial - 10
Culverts, Bridges, Channels and Creeks	Any type of area less than 1,000 acres	25
Culverts, Bridges, Channels and Creeks	Any type of area greater than 1,000 acres	100

*If in a storm drain system, an inlet is at a low point so that flow in excess of the storm drain capacity would be directed onto private property, and such overflows could cause damage or serious inconvenience in the opinion of the City Engineer, the design frequency shall be twenty-five (25) years.

1002.4 Underground drainage facility design

The developer shall calculate underground drainage facility (storm drain) capacity by Manning's Formula as follows:

$$Q = \frac{1.486}{n} AR^{2/3} S^{1/2}, \quad \text{where:}$$

Q = the discharge in cubic feet per second;
A = the cross-sectional area of flow in square feet;
R = the hydraulic radius in feet = area/wetted perimeter;
S = the slope of the hydraulic gradient in feet per foot;
n = the coefficient of roughness.

The elevation of the hydraulic gradient of the storm sewer shall be a minimum of 1.5 feet below the elevation of the adjacent street gutter. The developer shall use storm water pipe sized so that the average velocity in the pipe will not exceed eight (8) feet per second.

TABLE 10-4
TIME OF CONCENTRATION

$$T = \frac{D}{Vx60}$$ where:

T = Time of concentration in minutes for use in Table 10-4. The minimum time of concentration shall be ten (10) minutes.

D = Distance in feet from point of concentration to the hydraulically most distant part of the drainage basin under construction.

V = Velocity in feet per second from Section 1002.2, or velocity calculated by an engineer for streets and/or storm sewers.

TABLE 10-5
COEFFICIENT OF ROUGHNESS

Open Channels		Maximum Permissible Velocity in Feet/Second	Coefficient "n"
Paved			
	Concrete	8	0.011 to 0.020
	Asphalt	8	0.013 to 0.017
	Rubble or Riprap	8	0.017 to 0.030
Earth			
	Bare, sandy silt, weathered	2.0	0.020
	Silt clay or soft shale	3.5	0.020
	Clay	6.0	0.020
	Soft sandstone	8.0	0.020
	Clean gravelly soil	6.0	0.030 to 0.150[1]
Turf			
	Shallow Flow	6.0	0.06 to 0.08
	Depth of flow over 1 foot	6.0	0.04 to 0.06

From: "Town Branch Drainage Study - Huntsville, Texas" Dec. 1975 by O'Malley and Clay, Inc.

[1] Will vary with straightness of alignment, smoothness of bed and side slopes, and whether channel has light vegetation or is choked with weeds and brush.

1002.5 Open channel design

The developer shall design and construct open channel facilities based on frequencies shown in Table 10-3 and calculated by Manning's Formula with roughness coefficients and velocities as shown in Table 10-5. Side slopes of channels shall be no steeper than 3:1 in earth and 1:1 when lined with concrete.

1002.6 Culvert design

A developer shall install enclosed culverts if a creek or ditch crosses proposed roadway improvements. The developer shall determine the quantity of flow to be carried by the culvert by the Rational Formula. The size of the culvert required shall be the larger size indicated by the inlet and outlet flow control.

Design of culverts shall include the determination of upstream backwater conditions, downstream velocities and flooding conditions. The developer shall not design or install culverts with discharge velocities that exceed those provided in Table 10-6.

1003. MINIMUM DESIGN STANDARDS

The design requirements set forth in this chapter are minimum design standards. The City Engineer may require additional precautions or treatments consistent with sound engineering practice to provide for conditions not specifically covered in this chapter.

TABLE 10-6
CULVERT DISCHARGE - VELOCITY LIMITATIONS

Culvert Discharging On To	Maximum Allowable Velocity (f.p.s.)
Earth	6
Sod Earth	8
Paved or riprap apron	8
Shale	8
Rock	8